

CLAIMS:

1. A process for fabricating a micro-electro-mechanical system composed of fixed components fixedly supported on a base and movable components movably supported on said base;

said process comprising the steps of:

- 1) providing a upper semiconductor substrate (10) and a lower substrate (20) which defines said base;
- 2) selectively etching a top layer (12) in said upper semiconductor substrate to form therein a plurality of posts which project commonly from a bottom layer (14) of said upper semiconductor substrate, said posts including said fixed components (30) to be fixed to said lower substrate and said movable components (40) which are resiliently coupled to one or more of said fixed components to be movable relative to said lower substrate;
- 3) selectively etching a top surface of said lower substrate to form therein at least one recess (22);
- 4) bonding said upper semiconductor substrate on top of said lower substrate with said upper semiconductor substrate upside down in such a manner as to place said fixed components directly on said lower substrate and to place said movable components upwardly of said at least one recess; and
- 5) removing said bottom layer from said upper semiconductor substrate to release said movable components from said bottom layer for floating said movable components above said at least one recess and allowing them to move relative to said lower substrate, while keeping said fixed components fixed to the top of said lower substrate.

2. The process as set forth in claim 1, wherein said bottom layer (14) of said upper semiconductor (10) substrate is removed firstly by abrasion and subsequently by etching.

3. The process as set forth in claim 1, wherein said upper semiconductor substrate is of a SOI (silicon on insulator) structure having a buried oxide layer (16) extending between said top layer (12) and said bottom layer (14), said upper semiconductor substrate being etched to form said fixed and movable components (30, 40) that are be supported on said bottom layer through said buried oxide layer, said bottom layer (14) and said buried oxide layer (16) being removed after said upper semiconductor substrate (10) is bonded to said lower substrate (20).

4. The process as set forth in claim 3, wherein said bottom layer (14) is removed at least partially by abrasion, while said buried oxide layer is removed by etching.

5. The process as set forth in claim 3, wherein said bottom layer (14) is removed partially by abrasion followed by being etched

to the buried oxide layer, and said buried oxide layer (16) is dry-etched by a method different from that for etching said bottom layer.

6. The process as set forth in claim 3 , wherein
said buried oxide layer (16) is removed by a dry-etching.

7. The process as set forth in claim 3 , wherein
all of said fixed and movable components have uniform height standing from said buried oxide layer.

8.. The process as set forth in claim 3 , wherein
said fixed and movable components (30, 40) projecting on said buried oxide layer (16) are covered with an oxidized coat (18), said oxidized coat (18) having a thickness less than said buried oxide layer (16) and being etched away in order to smoothen the faces of said fixed and movable components (30, 40) prior to said upper semiconductor substrate (10) being bonded to said lower substrate (20).

9 . The process as set forth in claim 1, wherein
at least one of said upper semiconductor substrate (10) and said lower substrate (20) is formed at the interface therebetween with a groove (26) which extends to

the exterior of said system from within an interior space confined between said upper semiconductor substrate (10) and said lower substrate (20) for making said interior space open to the exterior of the system.

10. The process as set forth in claim 1, wherein said movable components (40) are formed in said top layer (12) of the upper semiconductor substrate to have a height shorter than said fixed components (30).

11. The process as set forth in claim 10, wherein said upper semiconductor substrate (10) is covered with a composite mask composed of a first mask (52) covering a portion later formed into said fixed component (30) and a second mask (54) covering a portion later formed into said movable component (40) and also said first mask (52), said composite mask being etched together with the top layer (12) of said upper semiconductor substrate (10) to such an extent as to reduce the height of the movable component (40) relative to that of the fixed component (30).

12. The process as set forth in claim 11, wherein said first mask (52) is made from a material which is etched at a low etching rate than said second mask (54).

13. The process as set forth in claim 1, wherein said upper semiconductor substrate (10) is processed to smoothen the side faces of said posts, prior to being bonded to said lower substrate (20).

14. The process as set forth in claim 1, wherein said lower substrate (20) is covered on its top with a dielectric layer (24).

15. The process as set forth in claim 14, wherein said lower substrate is made of a semiconductor material and is formed on its top surface with an oxide layer which defines said dielectric layer.

16. The process as set forth in claim 1, wherein said lower substrate is made of a dielectric material.

17. The process as set forth in claim 1, wherein said upper semiconductor substrate (10) is processed to cover said fixed and movable components (30, 40) with an etching-shield (74) prior to being bonded said lower substrate such that said components are protected from being etched away during the removal of said bottom layer from said upper semiconductor substrate.

18. The process as set forth in claim 17 , wherein said etching shield (74) is firstly formed on the entire exposed faces of said components (30, 40) and removed after said components (30, 40) are released from said bottom layer (14).

19. The process as set forth in claim 1, wherein said upper semiconductor substrate (10) is of a SOI (silicon on insulator) structure having a buried oxide layer (16) extending between said top layer (12) and said bottom layer(14), said upper semiconductor substrate (10) being etched to form in its top layer (12) dummy projections (19) between said components, said dummy projections (19) having a width smaller than said components (30, 40) and being anchored to said buried oxide layer (16), said buried oxide layer (16) confined between said dummy projections (19) and said bottom layer (14) being etched away to release said dummy projections, prior to said upper semiconductor substrate being bonded to said lower substrate.

20. The process as set forth in claim 1, wherein said upper semiconductor substrate (10) is etched in its top layer (12) to form a plurality of said posts (30, 40) which leave cavities (15) in said top layer between the adjacent ones of said posts, said cavities having different depths,

said upper semiconductor substrate is etched in its bottom to form a plurality of shelves (17) which project on the bottom of said upper semiconductor substrate in registration with deep ones of said cavities (15), said shelves (17) having a thickness which is proportion to the depth of the associated cavities, said bottom layer (14) is etched away together with said shelves (17), after said upper semiconductor substrate is bonded to said lower substrate, to release said movable components and fixed components from said bottom layer.

21. The process as set forth in claim 1, wherein said upper semiconductor substrate (10) is etched in its top layer to form a plurality of said posts (30, 40) to leave cavities (15) in said top layer between the adjacent ones of said posts, said cavities having different depths, said upper semiconductor substrate is covered on its bottom with masks (17A) which cover areas in registration with said cavities, said masks having a thickness which is proportion to the depth of the associated cavities, said top layer is etched away together with said mask, after said upper semiconductor substrate is bonded to said lower substrate, to release said movable components and said fixed components from said bottom layer.

22. The process as set forth in claim 1, wherein said upper semiconductor substrate (10) is embedded with a dielectric member (53) which penetrates through the top layer (12), said dielectric member (53) being confined within a portion to be later formed into said post (30, 40) in order

to electrically divide the associated component into two zones for electrical insulation therebetween and to keep said zones mechanically integrated with each other,

said upper semiconductor substrate is etched in its top layer to form said post with said dielectric member kept embedded in said post which is finally formed into one of said movable and fixed components (30, 40) by removal of said bottom layer (14) from said upper semiconductor substrate (10).

23. A micro-electro-mechanical system comprising:

a lower substrate (20);

an upper substrate (10) bonded on to said lower substrate, said upper substrate being composed of fixed components (30) fixed to said lower substrate, and movable components (40) that are resiliently coupled to one or more of said fixed components to be movable within a plane of said upper substrate relative to said lower base,

said movable components (40) being adapted to receive an electric potential relative to said fixed components for developing an electrostatically attracting force by which said movable components are drive to move;
said lower substrate (20) being formed in its top surface with at least one recess (22) above which said movable components are located.

24. The system as set forth in claim 23, wherein

said fixed and movable components have generally identical height to make their lower ends aligned at the interface between said upper substrate and said lower

substrate.

25. The system as set forth in claim 23, wherein at least one groove is formed at the interface between said lower substrate and said upper substrate to extend to the exterior of said system from within an interior space confined between said lower substrate and said upper substrate for making said interior space open to the exterior of the system.